THE COASTAL BARRIER ISLAND NETWORK (CBIN): FUTURE MANAGEMENT STRATEGIES FOR BARRIER ISLANDS

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Introduction

Barrier islands are ecosystems that border coastal shorelines and form a protective barrier between continental shorelines and the wave action originating offshore. In addition to forming and maintaining an array of coastal and estuarine habitats of ecological and economic importance, barrier island coastlines also include some of the greatest concentrations of human populations and accompanying anthropogenic development in the world. These islands have an extremely dynamic nature whereby major changes in geomorphology and hydrology can occur over short time periods (i.e. days, hours) in response to extreme episodic storm events such as hurricanes and northeasters. The native vegetation and geological stability of these ecosystems are tightly coupled with one another and are vulnerable to storm-related erosion events, particularly when also disturbed by anthropogenic development.

Emerging Themes for Future Management Strategies

The Coastal Barrier Island Network (CBIN) is an international research group dedicated to creating solutions involving a strategic compromise between anthropogenic development and preservation of the natural ecosystem (www.coastalbarrierisland.org). CBIN had their second meeting in Galveston, Texas in January 2009 following Hurricane Ike. The goal of this meeting, as well as the first meeting in Biloxi, Mississippi following Hurricane Katrina, was to develop a research-management-outreach framework for sustaining coastal barrier ecosystems under global change predictions (i.e. increased storm activity) and continued anthropogenic stresses. The location of the second meeting provided an opportunity to observe first-hand post-hurricane damage on the Chenier Plain, Bolivar Peninsula, and Galveston Island. In the context of viewing Hurricane Ike's impact upon coastal ecosystems, the following six major themes emerged from the 2009 CBIN meeting, identifying critical areas for future research and science-based management decisions for the Atlantic Ocean and Gulf of Mexico coasts of the USA.

1. **There are critical differences between natural and human-dominated barrier island landforms and ecosystems due to biophysical processes, spatial and temporal dynamics, and anthropogenic modifications.**

Coastal ecosystems are the product of biotic and abiotic processes and interactions, including longshore drift, sediment transport, island retreat, vegetation succession, and episodic destructive storms. Anthropogenic forces that serve to reduce or redistribute sediment to the beach and dune system can alter the size, location, and heterogeneity of both landforms and species and their behavior. Thus, it is not only necessary to consider the processes that give rise to the assemblages of landforms and species in the coastal zone, but also the interactions between natural processes and human modifications that can enhance or inhibit ecosystem function (Nordstrom et al. 2007). At some locations on Bolivar Peninsula and Galveston Island, examples of how natural forces combined with human management efforts exacerbated the destructive impact of Ike were evident. For example, on sections of Bolivar Peninsula, overwash deposits were evident along the main highway, and the sites of several overwash breaches corresponded to the positioning of gaps in the geotube barrier (large textile tubes filled with sand) that had been placed along many sections of the beach. Though the connection between the anthropogenic modifications and natural processes is not always as clear as this example, it demonstrates the importance of developing models of natural-human processes and feedbacks on developed coastal barrier systems.

2. **The processes that influence vulnerability and resilience of coastal barrier ecosystems must be better understood across a broad spectrum (micro- to macro-scale) of spatial and temporal scales.**

In coastal systems, sustainability is often understood in terms of resilience (Turner et al. 2003), i.e. whether a system can re-establish its structure and function when re-worked by anthropogenic and natural processes occurring at various scales. Thus, the vulnerability and resilience of coastal barriers needs to be examined across a spectrum of spatial and temporal scales when assessing the effectiveness of management decisions. The time scales considered are dependent upon the processes that are being analyzed. Hurricanes are episodic events, and thus their impacts should be incorporated into long-term planning. Furthermore, coastal sediment budgets and longshore drift should be considered at broad spatial and temporal scales. For example, the seawall in Galveston was designed to protect landward infrastructure but has subsequently altered the sediment transport dynamics of the island. The jetties to the east of the seawall have prevented transport of sediment to down-drift beaches, which have ultimately prevented transport of sediment to the west end of Galveston. Chronic sand deprivation caused flanking or excessive recession of the shoreline on the western end of the seawall, leading to local failure of the seawall during Hurricane Ike.

3. **Economic valuation tools such as cost-benefit analysis and rapid assessment methods utilizing remote sensing, GIS, and field-validation techniques can be used to generate collaborative solutions for advocates of different stakeholder perspectives.**

Potential conflicts in coastal management decisions often center on the controversies between desires for anthropogenic development versus desires for ecological sustainability. Achieving sustainable outcomes requires an approach that is inclusive rather than exclusive. One possible solution is to quantify the monetary value of ecosystem services (i.e. infrastructure protection by established dune systems, fisheries habitat created by healthy aquatic environments, and flood protection by functioning wetlands) and incorporate this value into the economic market, including costs due to the destruction of resources with high economic value (Costanza and Farley 2007). Another option is to create a geohazards map, such as the map of Galveston Island produced by the Bureau of Economic Geology (Gibeaut et al. 2007), that can be used to show critical areas prone to destruction by classifying areas of imminent threat that should be excluded from future development (i.e. wetlands, natural dune and beach ridges, and exposed sandy beaches) and areas of low threat that are suitable for development. This map, along with data on the potential for a category 4 or 5 hurricane, the value of tourism, and the overall impact to the ecosystem service values of the area, can enable more informed decisions that will benefit the overall community and ecosystem. Yet another solution is to use an efficient method based on remote sensing, GIS, and field validation techniques to create an index for rapid assessment of the current vulnerability and resilience of an area. This rapid assessment index would allow managers, public-policy decision-makers, and scientists to more easily compare different circumstances and areas. Two current examples include the U.S. Geological Survey National Assessment of Coastal Change program (http://coastal.er.usgs.gov/coastal-classification/) and the U.S. Environmental Protection Agency Index of Biotic Integrity used to assess streams (http://www.epa.gov/bioindicators/html/ibi-hist.html).

4. **We need new mechanisms for communicating more effectively with stakeholders (decision makers, government agencies, teachers, local public, developers, etc.) about emerging science and the implementation of management strategies.**

The scientific community has established many ideas of how to manage barrier island ecosystems for sustainability, but it is difficult to reconcile these ideas with the reality that stakeholders and decision makers face. New mechanisms for communication and dialogue about emerging barrier island science (i.e. tangible products such as maps, pamphlets, and websites) are needed to create management strategies that include emerging science (Daniels and Walker 2001). For example, on Bolivar Peninsula, community discussion focused on whether to rebuild mid-to-low income housing developments that were completely destroyed by Hurricane Ike or to allow these areas to evolve naturally instead of rebuilding and continuing the pattern of developing the same doomed structures (Moore 2009). The future of barrier islands will depend on communication with local residents and decision makers on how to best rebuild after events like Hurricane Ike.

5. **We need to address the idea of managing for stabilization versus sustaining natural processes, along with a more integrated application of restoration alternatives that would include native flora and fauna.**

Most management practices do not consider the variety of options that lie between stabilizing barrier islands by anthropogenic means versus allowing the geo-biological processes to take their natural course. For example, a dune system with natural vegetation could be established which would protect infrastructure while simultaneously developing a functioning ecosystem. An effort should be made to blend both natural and human-centered perspectives into the management of barrier islands. An example of collaboration can be seen in the plans for rebuilding Texas Highway 87, which was destroyed by overwashed surge and sand during Hurricane Ike. The overwash caused salt water intrusion into the landward wetland, which is home to a vital migratory bird sanctuary. After Ike, the transportation and natural resource agencies worked together to determine a better management plan for the road, such as using it as an elevated barrier to replace the lost sand and prevent salt water intrusion to sustain the freshwater wetland ecosystem.

6. In the future, there is potential for the development of a unified conceptual framework for managing unconsolidated sediment coasts, although there is much work to be done towards reaching this goal.

By taking into account barrier island connectivity at multiple temporal and spatial scales, it should be possible to work towards a unified conceptual framework for soft-sediment coasts. The use of new management strategies is imperative for implementing the framework on a broad scale. For example, a policy could implement the complete restriction of permanent structures along the beach front and allow only portable housing, or prevent overdevelopment in risky areas. Another strategy would be to reform tax, subsidy and insurance policies to discourage development (Bagstad et al. 2007). A systems approach framework would allow for a stronger and more precise management strategy that would take into consideration the overall ecological integrity of a barrier island and the coast as a whole. However, several questions remain to be answered prior to developing this broad framework. For example, what is the appropriate scale at which to create development policies? Is it better to start at the local scale and work upward to create policies (bottom-up) or to start with concepts such as “stabilization versus sustainability” and work towards the specifics (top-down)? Should development policies cover the entire coastline or only portions? Can coasts be developed in a way that maintains ecosystem functioning while creating smart growth development?

Conclusion

Hurricane Ike has provided examples of infrastructure and environmental impacts that occur when natural forces are combined with the presence of anthropogenic modifications. Six major themes emerged from the second CBIN meeting in Galveston, Texas, that are intended to serve as focus points for developing better management strategies. These themes consist of balancing natural and human processes, incorporating broad spatial and temporal scales to assess ecosystem sustainability and resilience, initiating multiple stakeholder communication and collaboration, utilizing natural restoration ideas for stabilization of barrier islands, and developing a comprehensive unified conceptual framework to manage our coastal ecosystems.

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This paper is summarized (with permission) from Williams et al. 2009.

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